

TABLE OF CONTENTS
LOW LEVEL SEWERSHED STUDY AND PLAN

Table of Contents

| | |
|-------------------------------------------------------------------------|------|
| Executive Summary | ES-1 |
| 1.0 Project Description | 1-1 |
| 1.1 Project Background | 1-1 |
| 1.2 Sewershed History/Previous Studies | 1-2 |
| 1.3 Purpose of Sewershed Study | 1-4 |
| 1.4 Description of the Sewershed and Sub-Basins | 1-4 |
| 1.5 Collection System Components and Attributes | 1-6 |
| 2.0 Effectiveness of Paragraph 8 Construction Projects | 2-1 |
| 3.0 Flow Monitoring Program | 3-1 |
| 3.1 Overall Description | 3-1 |
| 3.2 Metering Network within the Low Level Sewershed | 3-1 |
| 3.3 Rainfall Measurement..... | 3-3 |
| 3.4 Doppler Radar Analysis | 3-4 |
| 3.5 Data Collection, Data Processing, and QA/QC Process | 3-5 |
| 3.6 Dry Weather Analysis | 3-5 |
| 3.6.1 Base Infiltration Rates and Severity | 3-6 |
| 3.6.2 Correlation with Completed CCTV and Manhole Inspections | 3-11 |
| 3.6.3 Influence of Groundwater Table on Infiltration Rates..... | 3-11 |
| 3.6.4 Base Infiltration from Baltimore County | 3-11 |
| 3.7 Wet Weather Analysis | 3-11 |
| 3.7.1 Observed Peak Flows | 3-13 |
| 3.7.2 Rain Dependent I/I (RDII) Rates and Severity | 3-13 |
| 3.7.3 Correlation with Completed CCTV and Manhole Inspections | 3-15 |
| 3.7.4 RDII from Baltimore County | 3-15 |
| 3.7.5 Smoke Testing Recommendations..... | 3-16 |
| 3.8 Low Level Sewershed Infiltration and Inflow Evaluation Report | 3-16 |
| 4.0 Sewer System Evaluation Study | 4-1 |
| 4.1 Overall Description | 4-1 |
| 4.2 Manhole Inspections..... | 4-2 |
| 4.3 Sewer Cleaning and Closed Circuit Television Inspection | 4-5 |
| 4.4 Force Main Inspections..... | 4-9 |
| 4.4.1 Eastern Avenue Pumping Station Force Mains | 4-9 |
| 4.4.2 Locust Point and McComas Street Pumping Station Force Mains | 4-9 |
| 4.4.3 Grinder Pump Force Mains | 4-9 |
| 4.5 Smoke Testing..... | 4-10 |
| 4.6 Dyed-Water Testing..... | 4-12 |
| 4.7 Emergency Repairs/Rehabilitation..... | 4-13 |

TABLE OF CONTENTS
LOW LEVEL SEWERSHED STUDY AND PLAN

| | |
|-----------------------------------------------------------------------------|------|
| 4.8 Pumping Station Evaluations | 4-15 |
| 4.9 Data Quality Assurance/Quality Control Procedures..... | 4-15 |
| 4.9.1 Manhole Inspection QA/QC Procedures..... | 4-15 |
| 4.9.2 CCTV Inspection QA/QC Procedures..... | 4-16 |
| 4.9.3 Smoke Testing QA/QC Procedures..... | 4-16 |
| 4.9.4 Dyed Water Testing QA/QC Procedures | 4-17 |
| 5.0 Hydraulic Modeling | 5-1 |
| 5.1 Model Network..... | 5-1 |
| 5.2 Model Calibration..... | 5-7 |
| 5.3 Baseline Analysis and Capacity Assessment..... | 5-9 |
| 5.3.1 Design Storms | 5-9 |
| 5.3.2 Definition of Deficiency..... | 5-10 |
| 5.3.3 Storm Simulations (All Storms)..... | 5-10 |
| 5.3.4 Identification of Hydraulic Deficiencies (All Storms)..... | 5-13 |
| 5.4 Alternative Analyses | 5-14 |
| 6.0 Geographic Information Systems (GIS) | 6-1 |
| 6.1 Overview of GIS | 6-1 |
| 6.2 Field Data and GIS Integration | 6-2 |
| 6.3 Office Research and GIS Updates..... | 6-4 |
| 6.4 QA/QC Review and Procedures | 6-5 |
| 6.5 GIS Certification | 6-5 |
| 7.0 Recommendations | 7-1 |
| 7.1 Decision Making Criteria..... | 7-1 |
| 7.2 Proposed Improvements..... | 7-4 |
| 7.2.1 Sanitary Sewer Overflow Structure Identification and Elimination..... | 7-5 |
| 7.2.2 Structural Deficiencies Identified | 7-5 |
| 7.2.3 Proposed Low Level Collection System Hydraulic Improvements | 7-6 |
| 7.3 Proposed Improvement Implementation Schedule..... | 7-8 |
| 7.4 Estimated Costs of the Proposed Improvement Projects | 7-10 |
| 7.4.1 Estimated Improvement Budget | 7-11 |
| 7.5 Sewershed Re-Inspection Program | 7-14 |
| 7.5.1 Re-Inspection Prioritization Scheme | 7-14 |
| 7.5.2 CCTV and Manhole Inspections..... | 7-15 |
| 7.6 Future Data Collection and Evaluation Services | 7-16 |
| 7.4.1 Long-Term Flow Monitoring | 7-17 |
| 7.4.2 Sewer Cleaning Program | 7-17 |
| 7.4.3 CCTV and Manhole Inspection Programs | 7-17 |
| 7.4.4 Root Control Program | 7-18 |
| 7.4.5 Fats, Oils, and Grease Control Program | 7-19 |

TABLE OF CONTENTS
LOW LEVEL SEWERSHED STUDY AND PLAN

List of Tables

| | |
|------------------------------------------------------------------------------------------|------|
| Table ES-1 – Proposed Improvement Projects Summary | ES-3 |
| Table 3.2.1 – Low Level Flow Meter Purpose and Installation History | 3-3 |
| Table 3.4.1 – Storms Selected for Doppler Radar Analysis | 3-5 |
| Table 3.6.1.1 – Dry Weather Analysis (Summer 2006)..... | 3-7 |
| Table 3.6.1.2 – Dry Weather Analysis (Winter 2007) | 3-8 |
| Table 3.6.1.3 – Dry Weather Analysis (Summer 2007) | 3-9 |
| Table 3.7.1 – Wet Weather Analysis | 3-12 |
| Table 4.2.1 – Manhole Condition Summary | 4-4 |
| Table 4.2.2 – General Manhole Defect Summary | 4-4 |
| Table 4.2.3 – Manhole Defect Location Summary | 4-5 |
| Table 4.3.1 – CCTV Defect Observation Summary | 4-8 |
| Table 4.3.2 – Sewer Structural Condition Rating Summary..... | 4-8 |
| Table 4.3.3 – Sewer Operation and Maintenance Condition Rating Summary | 4-8 |
| Table 4.4.1 – Low Level Sewershed Force Main Summary | 4-10 |
| Table 4.5.1 – Smoke Testing Defect Summary | 4-12 |
| Table 4.6.1 – Dyed-Water Testing Defect Summary | 4-13 |
| Table 5.3.3.1 – Peak Discharges/Velocities at EAPS | 5-11 |
| Table 5.3.3.2 – Peak Discharges/Velocities at Locust Point and McComas Pump Stations ... | 5-12 |
| Table 5.4.1 – Total Estimated Low Level Improvement Costs | 5-24 |
| Table 5.4.2 – Estimated Low Level Improvement Costs per Gallon SSO Removed | 5-25 |
| Table 7.1.1 – Condition and Criticality Factors | 7-2 |
| Table 7.1.2 – Criticality Factor Relative Importance Values | 7-3 |
| Table 7.2.2.1 – Manhole Condition and Criticality Assessment | 7-5 |
| Table 7.2.2.2 – Sanitary Sewer Condition and Criticality Assessment..... | 7-6 |
| Table 7.3.1 – Manhole Rehabilitation Implementation Schedule | 7-8 |
| Table 7.3.2 – Sanitary Sewer Rehabilitation Implementation Schedule | 7-9 |
| Table 7.3.3 – Hydraulic Improvement Schedule | 7-10 |
| Table 7.4.1.1 – Estimated Manhole Rehabilitation Improvement Budget | 7-11 |
| Table 7.4.1.2 – Estimated Sewer Rehabilitation and Replacement Budget | 7-12 |
| Table 7.4.1.3 – Estimated Hydraulic Improvement Budget | 7-14 |
| Table 7.5.2.1 – Sewershed Re-Inspection Implementation Schedule | 7-16 |

List of Figures

| | |
|----------------------------------------------------------------------------|------|
| Figure ES-1 – Condition/Criticality Matrix..... | ES-3 |
| Figure 1.4.1 – Location of Sewershed in the City | 1-5 |
| Figure 3.2.1 – Low Level Flow Monitoring Schematic | 3-2 |
| Figure 3.3.1 – Rain Gauge Network | 3-3 |
| Figure 3.7.2 – LL20 Scattergraph | 3-14 |
| Figure 4.7.1 – Sanitary Repairs Performed in the Low Level Sewershed | 4-14 |

TABLE OF CONTENTS
LOW LEVEL SEWERSHED STUDY AND PLAN

| | |
|----------------------------------------------------------------|------|
| Figure 7.1.1 – Condition/Criticality Matrix | 7-3 |
| Figure 7.6.4 – Low Level Sewershed Root Control Analysis | 7-19 |

List of Maps

- Map 1.5.1 – Low Level Sewershed Major Sewers and Pumping Stations
Map 3.2.1 – Low Level Flow Monitoring and Rain Gauge Network
Map 3.6.1 – Low Level Base Infiltration Severity Map
Map 3.7.1 – Low Level RDII Severity Map
Map 5.1.1.A – Northwest Low Level Model Network
Map 5.1.1.B – Northeast Low Level Model Network
Map 5.1.1.C – Southwest Low Level Model Network
Map 5.1.1.D – Southeast Low Level Model Network
Map 5.3.3.A – Northwest Low Level Storm Simulation Results (All Storms)
Map 5.3.3.B – Northeast Low Level Storm Simulation Results (All Storms)
Map 5.3.3.C – Southwest Low Level Storm Simulation Results (All Storms)
Map 5.3.3.D – Southeast Low Level Storm Simulation Results (All Storms)
Map 5.4.1.A – Northwest Low Level Alternative Analysis (2-yr Storm)
Map 5.4.1.B – Northeast Low Level Alternative Analysis (2-yr Storm)
Map 5.4.1.C – Southwest Low Level Alternative Analysis (2-yr Storm)
Map 5.4.1.D – Southeast Low Level Alternative Analysis (2-yr Storm)
Map 5.4.2.A – Northwest Low Level Alternative Analysis (5-yr Storm)
Map 5.4.2.B – Northeast Low Level Alternative Analysis (5-yr Storm)
Map 5.4.2.C – Southwest Low Level Alternative Analysis (5-yr Storm)
Map 5.4.2.D – Southeast Low Level Alternative Analysis (5-yr Storm)
Map 5.4.3.A – Northwest Low Level Alternative Analysis (10-yr Storm)
Map 5.4.3.B – Northeast Low Level Alternative Analysis (10-yr Storm)
Map 5.4.3.C – Southwest Low Level Alternative Analysis (10-yr Storm)
Map 5.4.3.D – Southeast Low Level Alternative Analysis (10-yr Storm)
Map 5.4.4.A – Northwest Low Level Alternative Analysis (15-yr Storm)
Map 5.4.4.B – Northeast Low Level Alternative Analysis (15-yr Storm)
Map 5.4.4.C – Southwest Low Level Alternative Analysis (15-yr Storm)
Map 5.4.4.D – Southeast Low Level Alternative Analysis (15-yr Storm)
Map 5.4.5.A – Northwest Low Level Alternative Analysis (20-yr Storm)
Map 5.4.5.B – Northeast Low Level Alternative Analysis (20-yr Storm)
Map 5.4.5.C – Southwest Low Level Alternative Analysis (20-yr Storm)
Map 5.4.5.D – Southeast Low Level Alternative Analysis (20-yr Storm)
Map 7.2.3.A – Northwest Low Level Recommended Hydraulic Improvements
Map 7.2.3.B – Northeast Low Level Recommended Hydraulic Improvements
Map 7.2.3.C – Southwest Low Level Recommended Hydraulic Improvements
Map 7.2.3.D – Southeast Low Level Recommended Hydraulic Improvements

TABLE OF CONTENTS
LOW LEVEL SEWERSHED STUDY AND PLAN

List of Attachments (on enclosed DVD)

Attachment 3.2.1 – Low Level Flow Meter Calibrations
Attachment 3.8.1 – I&I Evaluation Report
Attachment 4.2.1 – Low Level Manhole Inspection Reports and Database
Attachment 4.3.1 – Low Level CCTV Inspections (flexidata® Databases)
Attachment 4.5.1 – Low Level Smoke Testing Reports and Database
Attachment 4.6.1 – Low Level Dyed-Water Testing Reports and Database
Attachment 4.9.1 – Low Level Manhole Inspection QA/QC Manual
Attachment 4.9.2 – Low Level CCTV Inspection QA/QC Manual
Attachment 4.9.3 – Low Level Smoke Testing QA/QC Manual
Attachment 4.9.4 – Low Level Dyed-Water Testing QA/QC Manual
Attachment 5.2.1 – Low Level Model Calibration Report
Attachment 5.3.1 – Low Level Baseline Assessment and Capacity Analysis Report
Attachment 5.4.1 – Low Level Alternative Analysis Report
Flexidata® Installation
Low Level Sewershed Study and Plan – Electronic Copy